SWATH MAPPING OF THE NEW JERSEY AND NORTHERN CALIFORNIA MARGINS AND STATISTICAL CHARACTERIZATION OF THE SHELF AND SLOPE BATHYMETRY

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LONG TERM GOALS

• Demonstrate the utility of high resolution swath map data in the investigation of sedimentary processes in the continental shelf environment.
• Enable realistic interpolation of sparsely sampled bathymetric and stratagraphic data for use by the Navy in acoustic modeling.

SCIENTIFIC OBJECTIVES

• Provide a geologic framework for all STRATAFORM work related to the northern California and New Jersey natural laboratories.
• Formulate statistical models of shelf and slope bathymetric roughness.
• Develop methodology for interpolation of sparsely sampled bathymetric and stratagraphic data.

APPROACH

A "realistic" interpolation or extrapolation of bathymetry, i.e., an interpolation that honors the statistical character of the real data, is referred to as a "conditional simulation." The first step in generating a conditional simulation is derivation of a statistical model from the data. We typically employ the anisotropic von Kármán model (Goff and Jordan, 1988), which has proven appropriate for a wide variety of geophysical fields. However, refinements of this model have occasionally proven necessary, including the shelf northern California shelf morphology (Goff et al., in press). Once an appropriate statistical model has been selected, a conditional simulation can be generated by a variety of methods, including Fourier simulation, sequential Gaussian simulation, turning band methods, simulated annealing, and others. Part of the work conducted under this grant included a performance evaluation of Fourier and sequential Gaussian simulation, two of the more popular methods in the literature.

A realistic interpolation of 3-D stratagraphic geometry will require several steps. In addition to a reasonable statistical model for stratagraphic surfaces, the most critical information will be an estimate of coherency as a function of wavelength between adjacent strata (which can include the seafloor). Successive strata can then be generated which conform to the coherency criteria and which also conform to any hard constraints such as seismic or coring data. This work will be the focus of next year's efforts.

WORK COMPLETED

Structural interpretation and statistical analysis of the northern California and New Jersey margin swath mapping surveys were covered in the two previous progress reports. Preliminary results from the northern California survey were presented in Goff et al. (1997), and a more thorough analysis of the northern California shelf morphology is presented in Goff et al. (in press). Results from the New Jersey shelf survey are to be presented in Goff et al. (in prep.).

In collaboration with Dr. J. Jennings at the University of Texas Bureau of Economic Geology, a study has been completed comparing Fourier and sequential Gaussian methods of unconditional and conditional simulations (Goff and Jennings, submitted). Computer code has been developed for generating Fourier conditional simulations of two dimensional fields with arbitrary conditioning criteria, using the

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anisotropic von Kármán model as a basis, which has been found to be appropriate for the New Jersey shelf (Goff et al., in prep). This code is available for distribution from the PI. Work continues on incorporating modifications to the von Kármán model that are appropriate to the northern California shelf bathymetry.

RESULTS

In the comparison of sequential Gaussian simulation (SGS) and Fourier simulation (FS), the SGS method was by far the slowest of the two, and required careful trial-and-error manipulation of performance parameters to find the best compromise between runtime efficiency and simulation accuracy. The SGS's accurately matched the intermediate- and small-scale character of the intended second-order statistical model, but the unconditional SGS was deficient at larger scales, often but not always exhibiting a larger variance than expected apparently in response to a drift in the mean across the grid. The conditional SGS's did not exhibit any significant mean drift, possibly due to the constraint placed by the prior conditions.

The simple unconditional FS ran at far greater speed than the unconditional SGS. However, it failed to adequately match the intended statistical model at high wavenumbers due to sinc smoothing. We have formulated a modified FS method, which incorporates pre-aliasing of the wavenumber spectrum and a doubling of the Nyquist wavenumber (doubling simulation grid dimension while halving grid spacing, and then subsampling every second grid point). These modifications adequately correct sinc smoothing effects. We also devised a fast interpolation scheme for conditioning of the modified FS without the computational expense of full Kriging. The resulting conditional FS are more than 2 orders of magnitude faster than the corresponding conditional SGS's. We conclude that this modified FS method is superior to SGS due to its lack of mean drift problems, better computational performance, and more "hands-off" operation.

An example of a conditional FS using developed code is presented in Figure 1. The data used in this example are from the New Jersey swath map survey, in an area currently under investigation within the ONR Shallow Water Acoustics program.

IMPACT/APPLICATIONS

Conditional simulation of bathymetry and, eventually, stratagraphic geometry will enable acoustic modelers to generate a realistic model of the seabed environment with limited data input.

TRANSITIONS

It is expected that the software and expertise developed under this grant will be utilized by researchers in the Shallow Water Acoustics program.

RELATED PROJECTS

In collaboration with STRATAFORM investigators D. Swift, L. Mayer and N. Driscoll, the PI has recently submitted a proposal to the NOAA NURP, Mid-Atlantic Bight program for a submersible and sampling program within the New Jersey swath map survey area, for the purpose of ground truthing the sidescan sonar data and testing hypothesis for sand ridge and ribbon formation in the offshore environment.

REFERENCES

Goff, J. A., and J. W. Jennings, Simulating heterogeneity fields from stochastic models: A performance evaluation of Fourier and sequential Gaussian simulation methods, submitted to *Math. Geol*.

Goff, J. A., and T. H. Jordan, Stochastic Modeling of Seafloor Morphology: Inversion of Sea Beam data for second-order statistics, *J. Geophys. Res*., *93*, 13,589-13,608, 1988.

Goff, J. A., L. A. Mayer, J. Hughes-Clarke, and L. F. Pratson, Swath mapping on the continental shelf and slope: The Eel River basin, northern California, *Oceanograph*, *9*, 178-182, 1997.

Goff, J. A., D. L. Orange, L. A. Mayer, J. E. Hughes-Clarke, Detailed investigation of continental shelf morphology using a high resolution swath sonar survey: The Eel margin, northern California, *Mar. Geol*., in press.

Goff, J. A., D. J. P. Swift, C. L. Schuur, L. A. Mayer, and J. E. Hughes-Clarke, High resolution swath sonar investigation of sand ridge and sand ribbon morphology in the offshore environment of the New Jersey margin, manuscript in prep.

UTIG STRATAFORM website: http://www.ig.utexas.edu/research/projects/strataform.html

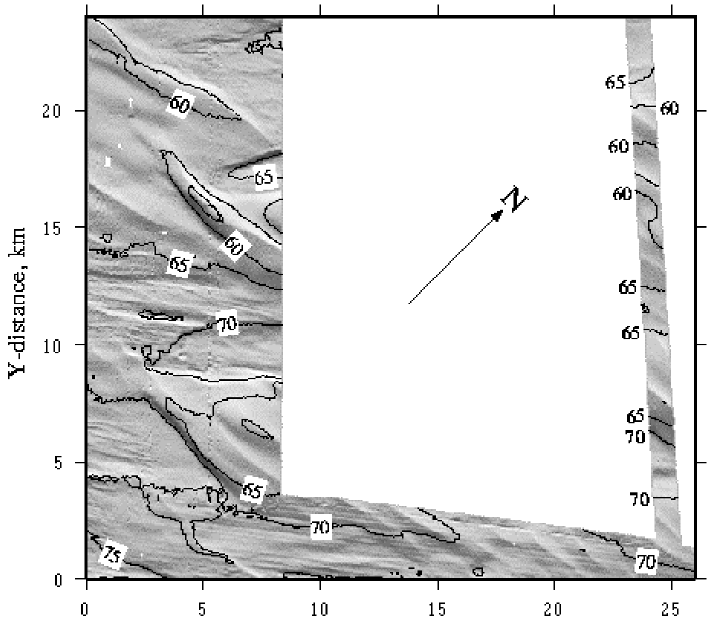

Figure 1a. Illuminated bathymetry from the STRATAFORM New Jersey swath sonar survey. Contours are in meters. Illumination is from the top of the image. Center of image is at approximately 39°25'N, 73°00'W.

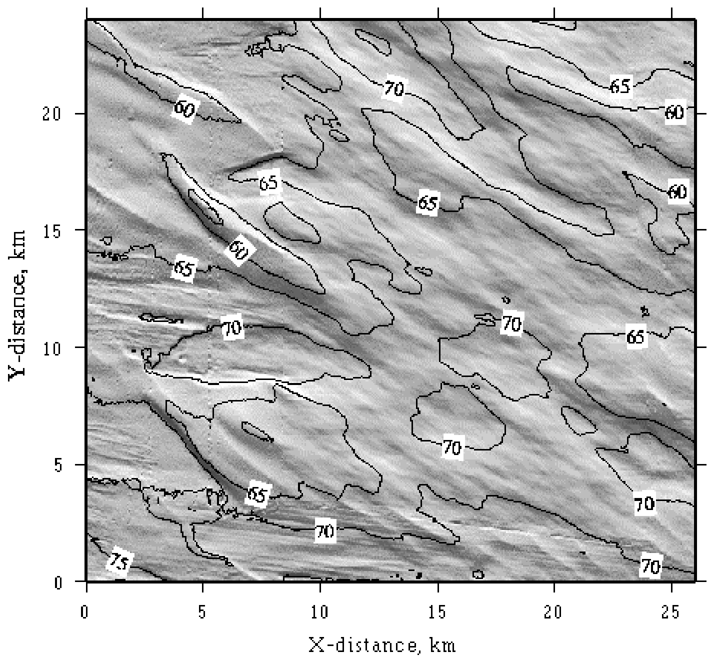

Figure 1b. Conditional simulation of above image, using statistical model derived from the data.